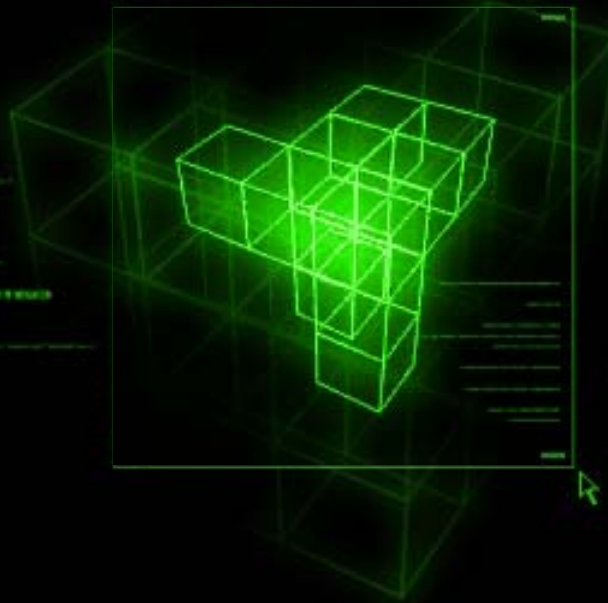


# Office of Distributed Energy Resources

## Fuel Cells for Buildings Program



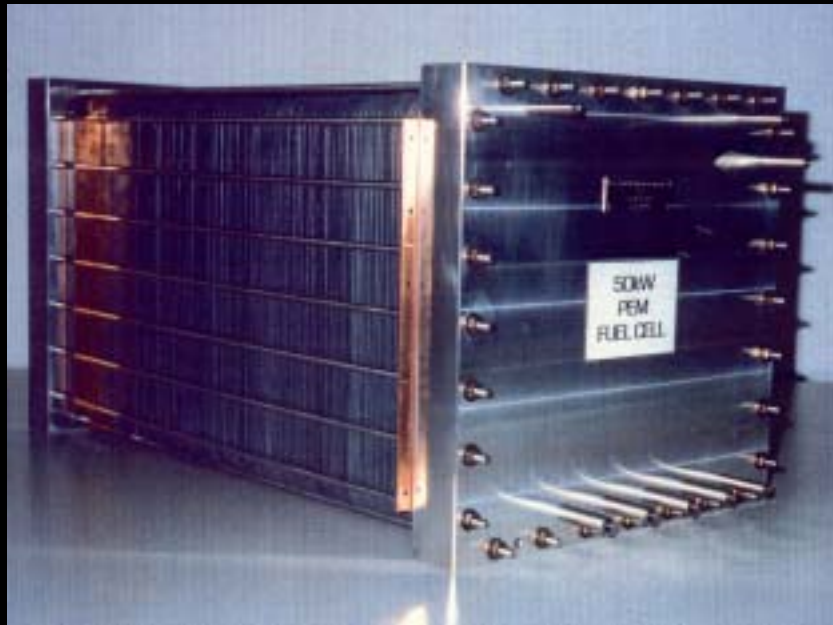
**Ronald Fiskum**  
**Program Manager**  
**Office of Power Technology**

# Program Goal

To build into the PEM fuel cells those characteristics that make it a prime component as a power generator and make maximum use of recoverable energy for cooling/heating and indoor air quality for various buildings types.

# Fuel Cell Types Low Temperature

## Proton Exchange Membrane



50 kW  
180°F

## Phosphoric Acid



200 kW  
400°F

# Fuel Cell Type High Temperature

## Solid Oxide



932°F to 1832°F

## Molten Carbonate

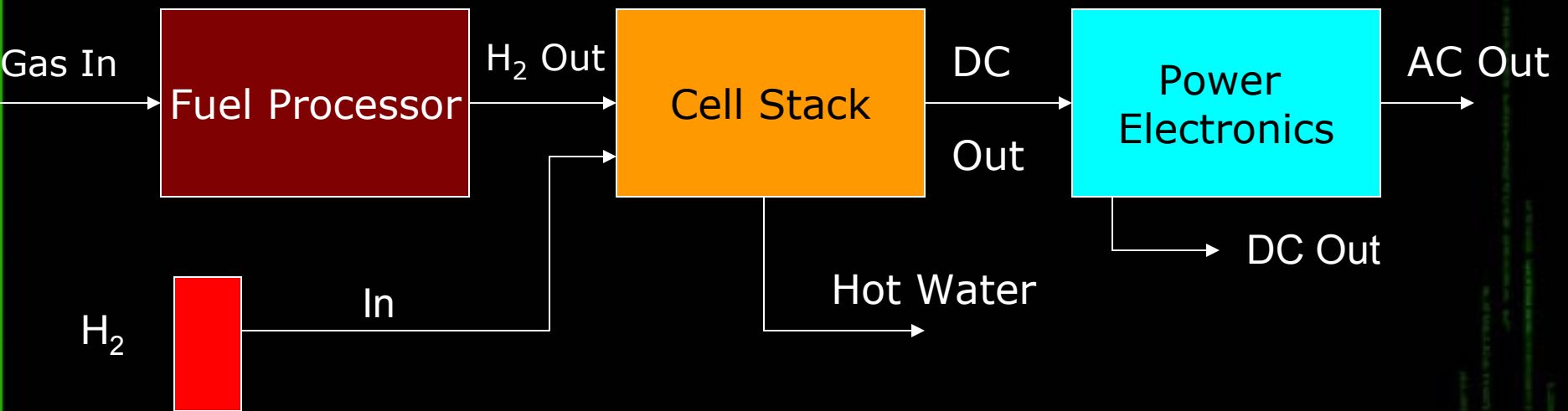


1200°F

# Fuel Cell Components



- Basic Components



**Proton Exchange Membrane (PEM)**

# Comparison- PEM



- **Cost**
- **Heat Recovery**
- **Reliability**
- **Battery Assist**
- **Fuel**
- **Load Follow**
- **Response Time**
- **Packaging**

## **Building**

\$1,500/kW

Important

40,000 hrs

No

Gas, Oil, Bio

Important

Important

Important

## **Automotive**

\$65/\$550

Optional

<5,000 hrs

Critical

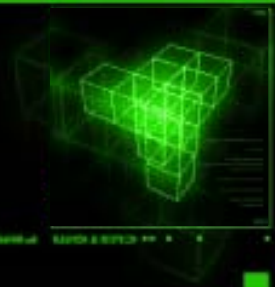
Liquid

Critical

Critical

Critical

# Basic Characteristics - Stationary



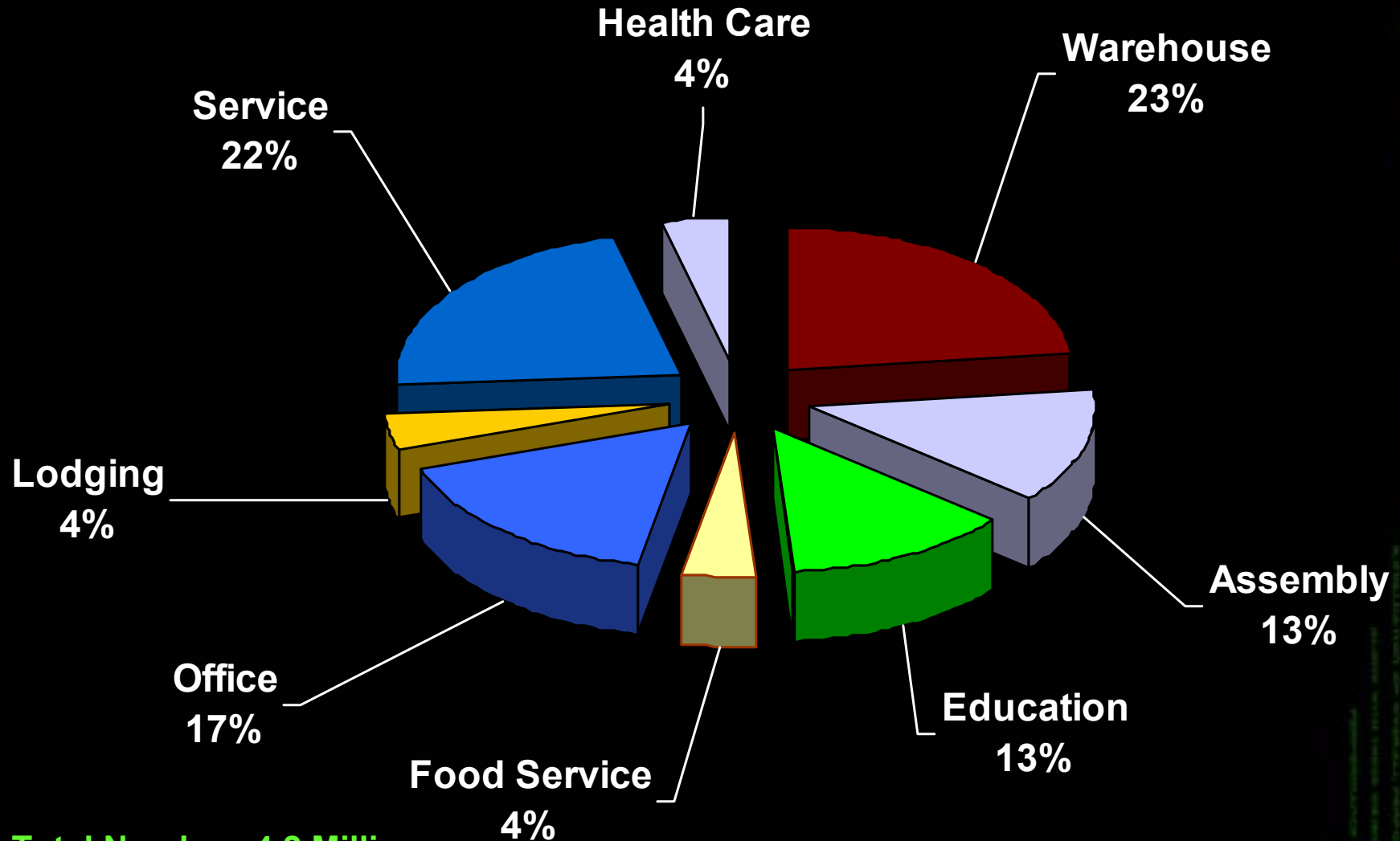
- Simple construction
- No heavy mechanical sub-systems
- Operating temperature 120°C – 140°C
- Operating pressure below 1.5 atm
- Operation 40,000 hrs
- Natural Gas, Oil, Propane, bio-gas, others  
high hydrogen content fuels

# Commercial Building Types



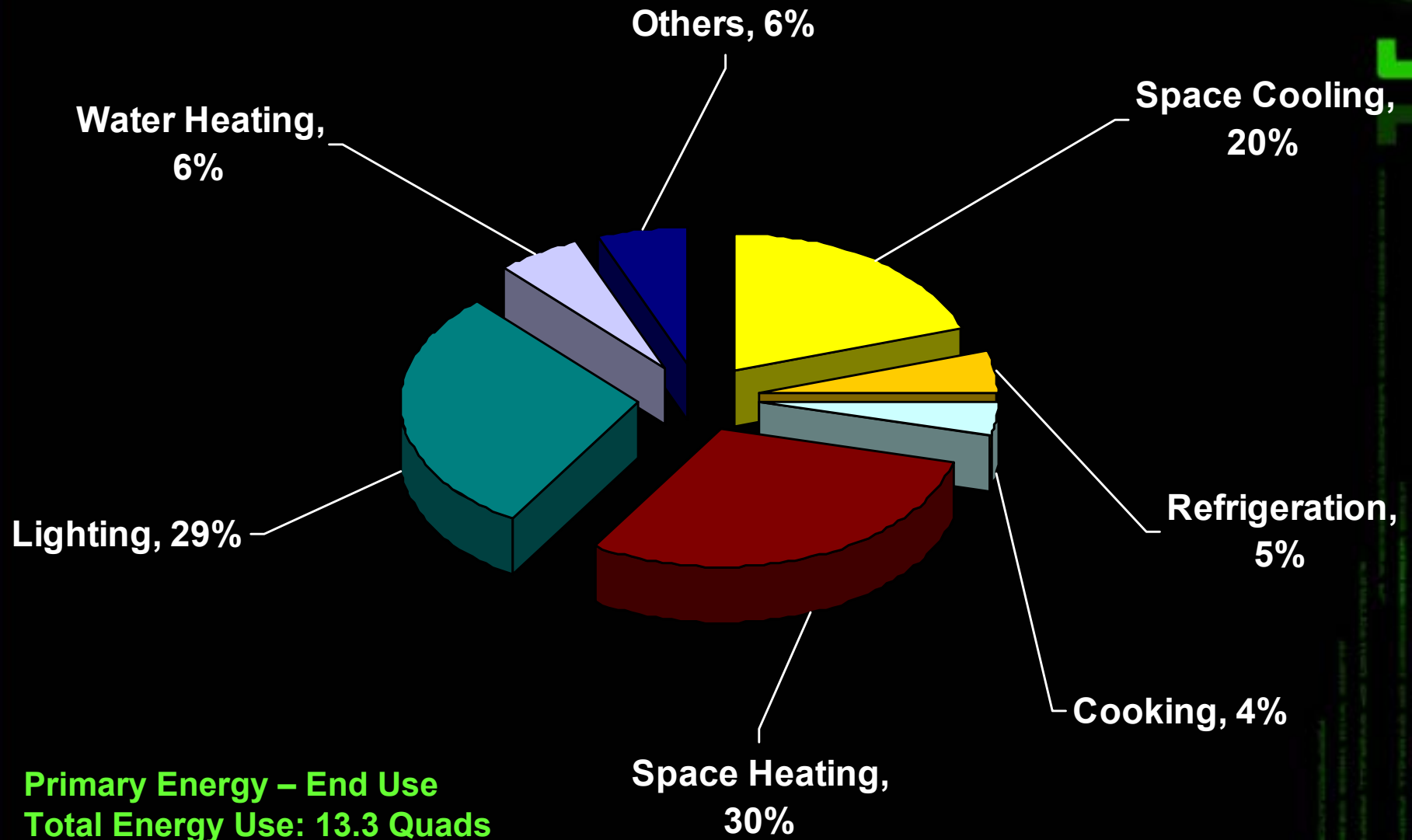
- Hotels/Motels
- Hospitals
- Office Buildings
- Retail Service
- Internet Server Farms
- Banks
- Credit Card processing centers
- Where the Electric/Thermal load are high

# Commercial Building Types

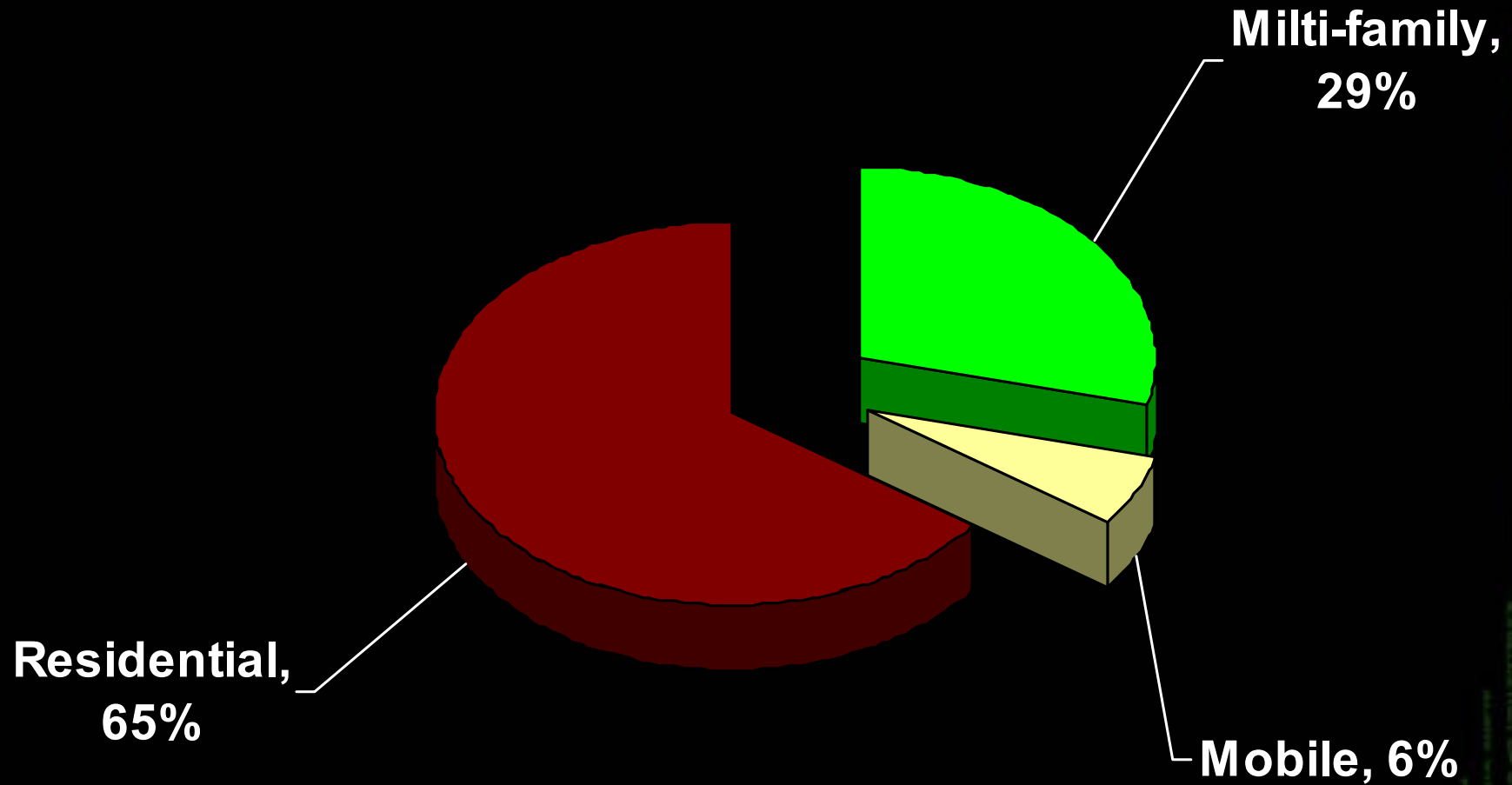


**Total Number: 4.2 Million**

# Commercial Consumption

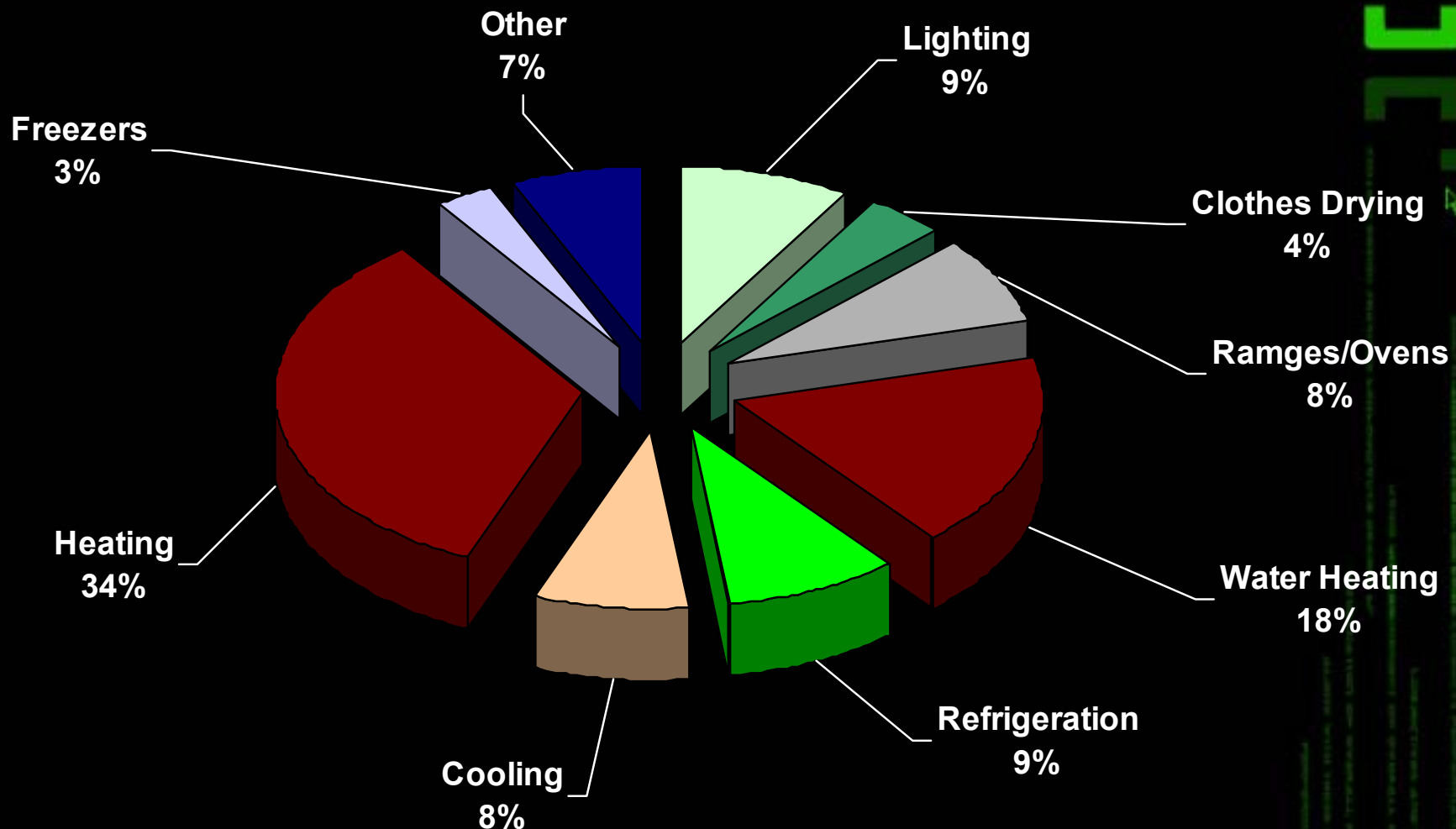


# Residential Building Types



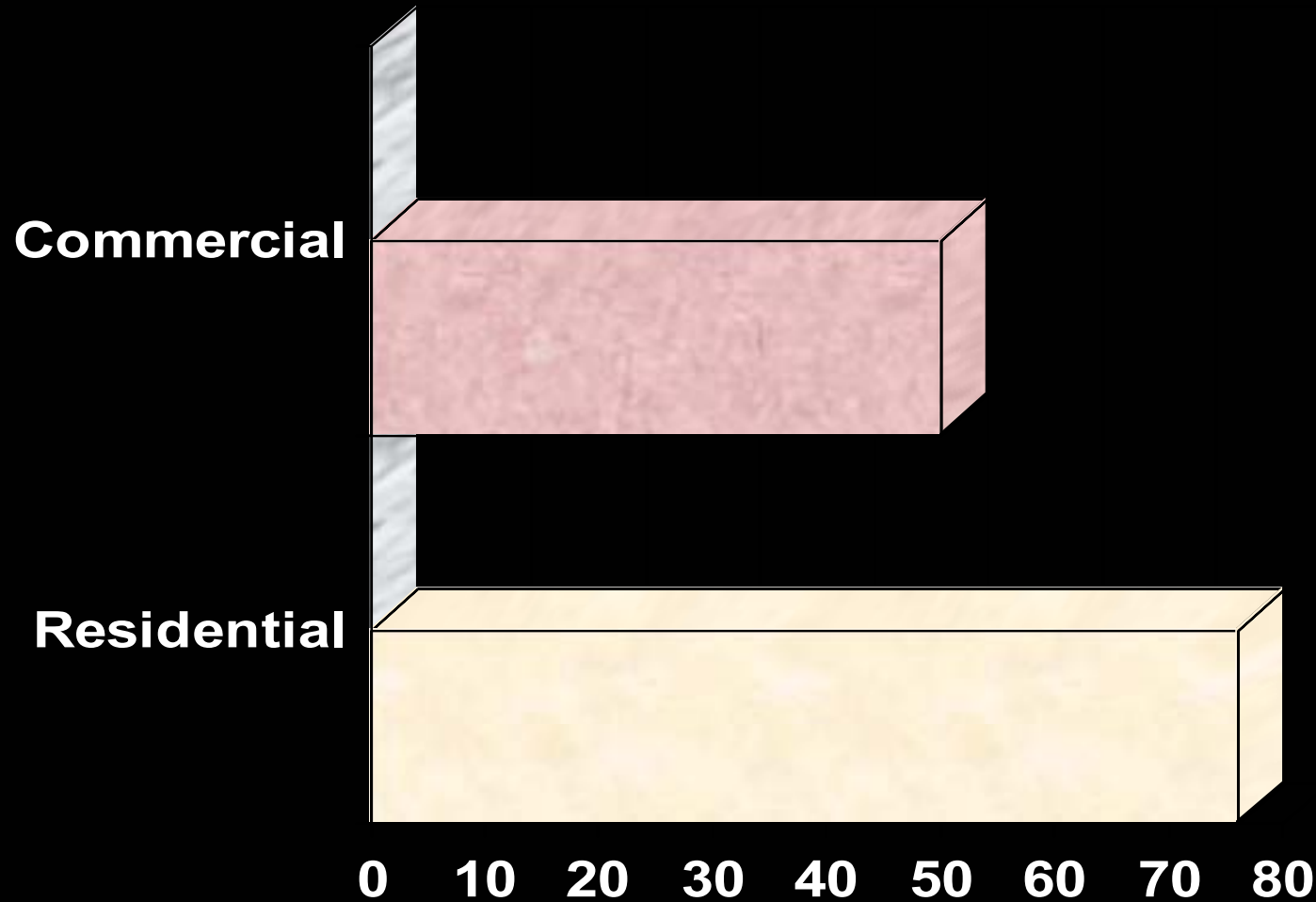
Source: 92 Million EIA 1989

# Residential Energy Consumption



Source: EIA - 1990

# Natural Gas Availability

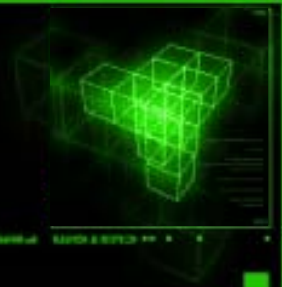


# Buildings Energy Consumption



- ~38% of natural gas consumption.
- ~67% of generated electricity consumption.
- ~36% of national primary energy consumption.

# Issues to be Addressed



- Endurance/Reliability
- Stack degradation
- Fuel reforming techniques
- Codes and standards
- Infrastructure
- Liability concerns (Insurance)
- Interconnect
- Start-up/Shut-down/Transient Operation
- Controls

# Issues to be Addressed



- Cost of system @ \$1,500/kW
- System efficiency 35%
- Competitive with other technologies
- System integration with building
- National security
- Stand alone operation/Grid connect
- 40,000 hrs of operation
- Code official training

# Needed Research



- High temperature membranes
- Bi-polar plates for high temperatures
- Low pressure operation
- Higher power density
- Uniform catalyst loading on membrane
- Water management, no humidification
- System controls
- Load following under variable loads

# Current Development Program



## High Temperature Membrane

- Fuel Cell Energy (formerly ERC)
  - **Danbury CT – ultra thin membrane**
- Foster Miller Associates
  - **Boston, MA – Micro composite membrane**

# Current Development Program Systems



- Arthur D. Little - Cambridge, Mass
  - **50 kW high temperature PEM fuel cell stack**
- Plug Power – Latham, NY
  - **50 kW high temperature scaleable PEMFC**
- Honeywell/GE – Torrance, CA
  - **50 kW High temperature integrated design**

# Current Development Program Fuel Reforming



- H2 Burner Tech, Long Beach, CA
  - **Under Oxidized Burner (UOB)**
- General Electric (EERC)– Irvine, CA
  - **Unmixed Reforming (UMR)**

# SBIR Programs



- **The Electro-synthesis Company, Inc**
  - **Development of Improved Oxygen reduction catalysts using combinatorial electrochemistry.**
- **Ion Power, Inc**
  - **New cathode electrodes for low-cost high temperature atmospheric air operated**
- **Fuel Cell Energy, Inc**
  - **Advanced cathode structure for Oxygen reduction**

# SBIR Programs

- **KSE, Inc**
  - **Novel catalyst for CO removal from fuel cell reformat**
- **Fuel Cell Energy, Inc**
  - **Novel regenerative CO polishing wheel**
- **Aspen Systems, Inc.**
  - **Novel sorption-reaction for CO removal.**



# Where does it Fit?



- Stationary Generation
  - **single user – single building**
  - **single user – multiple buildings**
- Distributed generation
  - **multiple users – multiple buildings**
- Remote settings

# Automotive Fuel Cell Program

## Fuel Processing

### Storage Subsystem

Fuel Processor R&D  
Micro-channel Components  
CO & Sulfur Management  
Catalyst R&D

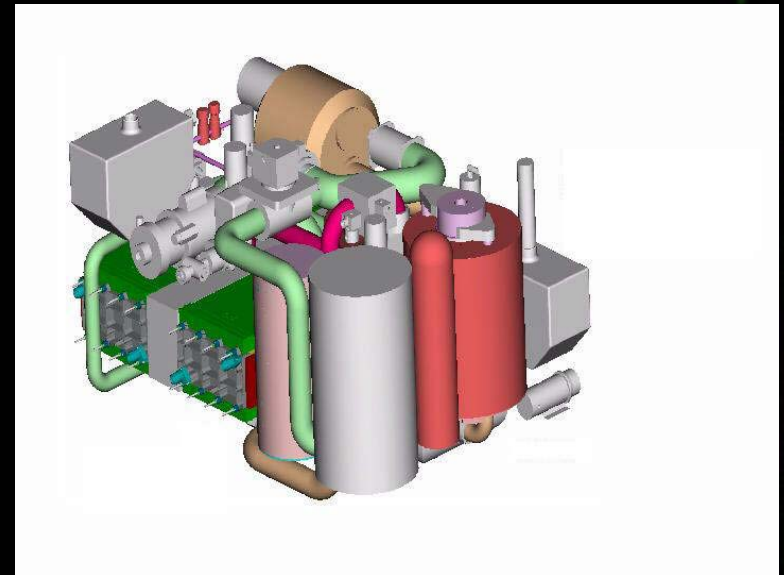
## Fuel Cell

### Stack Subsystem

High Temperature Membrane  
MEA/Bipolar Plate  
Cost Reduction R&D  
Durability Studies  
Direct Methanol Fuel Cells

## Systems

System Validation, Modeling  
Compressors, Sensors  
Cost Analyses  
Emissions Testing



# Hydrogen Program



## Barriers

- Codes and standards
- Safety
- Fuel choice
- Hydrogen delivery and refueling infrastructure

## Hydrogen Technology Integration

- Build transportation capacity of 1,000 vehicles
- Hydrogen fueling stations
- Establish regional infrastructure
- Promotion of hydrogen as transportation fuel

# National Energy Technology Lab



- **Fuel Cell Program**

Honeywell - a modular, 3- to 10-kilowatt solid oxide fuel cell wide range use

Siemens Westinghouse Power Corp.- a 7- to 10-kilowatt solid oxide residential

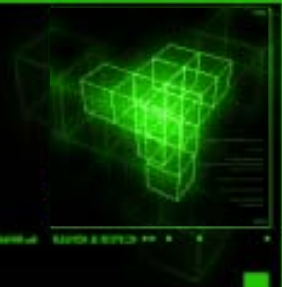
Siemens Westinghouse Power Corp.- a 3-to 10-kilowatt solid oxide automotive

Delphi Automotive Systems and Battelle - a solid oxide design for automotive and truck auxiliary power units

Cummins Power Generation and McDermott Technology, Inc.- 10-kilowatt system that is quiet, highly reliable, highly efficient, and emits virtually no pollutants.

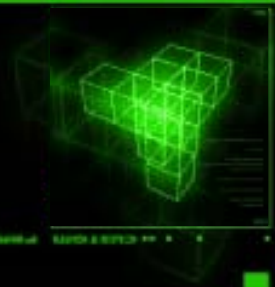
Honeywell International of Torrance, Calif To begin developing a new type of "planar solid oxide fuel cell" hybrid power system

# Benefits



- Emissions of green house gases minimized
- Alleviate blackout/brownouts
- Alleviate grid overload
- Reliable alternative energy source
- Onsite power generation
- Stand alone energy supply
- Modular

# Benefits

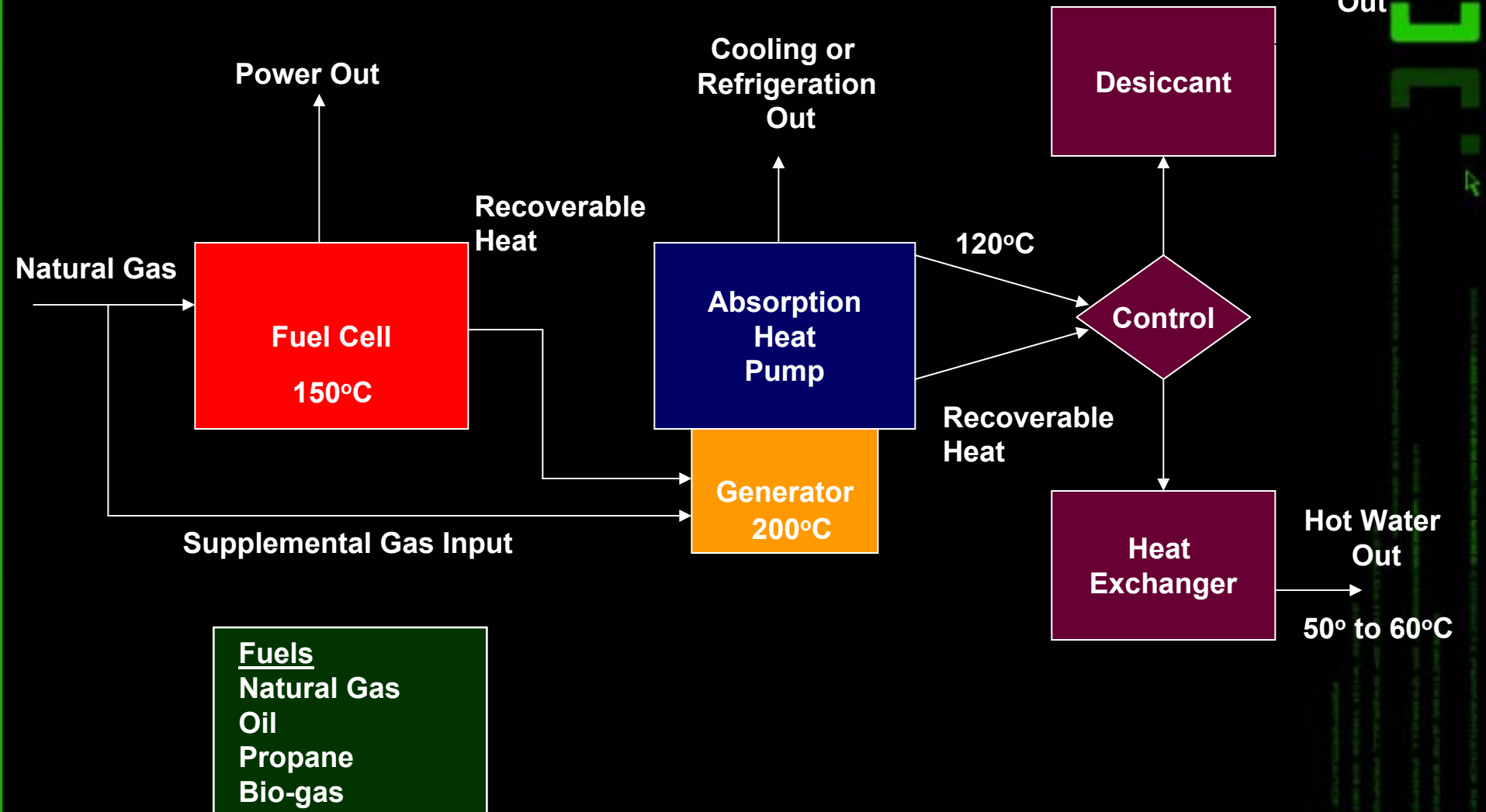


- Stand alone energy supply
- System efficiencies approaching 80%
- Premium Power – Uninterruptible
- International trade, job creation
- Centralized power generation
- Premium Power – Uninterruptible
- International trade, job creation

# Integrated Energy System



Dehumidification  
Out



# Codes and Standards



## Fuel Cell Summit VI – May 2002

- Objective: to facilitate the development and implementation of Codes and Standards necessary for Fuel Cell to be installed in buildings, mobile application or for on-site stationary use.



# Issues to be Addressed

- Field inspected prior to occupancy
- Owner operator
- Building codes integration
- Fuel mixes on site
- Training of field inspectors
- Training of Insurance agents



# Issues to be addressed

- International standards
- Standby or Emergency
- On site location
- Safety mechanisms
- Hydrogen storage on site
- Fire codes



# Office of Distributed Energy Resources

## Fuel Cells for Buildings Program



**Ronald Fiskum**  
**Program Manager**  
**Office of Power Technology**